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Mahogany and Kadam Planting Farmers in South Kalimantan: The Link Between Silvicultural Activity and Stand Quality

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Abstract This paper examines the relationship between farmers' socio-economic characteristics, silvicultural activity and the quality of their mahogany and kadam plantation stands in two independent case study villages in South Kalimantan Province, Indonesia. Data on farmers' socio-economic characteristics and silvicultural practices were collected and analysed by village using descriptive statistics, Mann–Whitney tests and Spearman correlations. Mahogany planters with larger areas planted carried out more silvicultural practices. Kadam planters who had joined the farmer's group earliest, had favourable or highly favourable attitudes towards tree planting, and whose households included more members gaining income were more active in silvicultural management. Approximately half of the studied mahogany and kadam plantations were of high quality. Most of the farmers conducted the recommended silvicultural practices, but just conducting them did not of itself cause the variation in the quality of stands. Pruning timing and recovery time after pruning, however, had an effect on the volume of potentially merchantable wood on medium quality mahogany sites. Further research is required on timing, frequency and methods used for the silviculture in order to improve the quality of stands. The policy implications drawn from this research include that farmers need to be provided with: (a) incentives to plant species with identified markets with reasonable price; (b) motivated extension officers; (c) improved access to production inputs; and (d) structures and mechanisms to assist them to organize and to develop activities, such as joint marketing.

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Introduction

The world's plantation forest area increased by 1.9% between 2000 and 2005 (Del Lungo et al. 2006). These plantations are needed to meet increasing timber demand, as well as providing environmental services and social benefits. In Indonesia, where the government has been promoting plantations, the area of plantation forest was 3.4 M ha in 2005 (Del Lungo et al. 2006), yet the Indonesian wood-based industry still faces a shortage of wood. In Indonesia some experiences of industrial tree plantation incentivies involving local people are already available in the literature, including partnership planting (e.g. Tyynelä et al. 2002; Nawir and Santoso 2005) and the Community Plantation Forest Programme, known locally as *Hutan Taman Rakyat* or HTR (Van Noordwijk et al. 2007). However, new information on tree planting experiences is needed to guide government officers and extensionists to improve implementation of tree planting programs, because the government of Indonesia has allocated 5.4 M ha of state production forest for conversion to the HTR program. This initiative is expected to involve directly about 360,000 rural households in the development of tree plantations (Emila and Suwito 2007).

Considering the large amount of wood that will be produced under the HTR program, it is important to study the possible wood quality coming from current smallholder plantation areas. Some authors have recorded that the productivity and quality of woodlots in the tropics are often below their potential (e.g. Varmola and Carle 2002; Bishwa and Garforth 2004; Van Noordwijk et al. 2007). The low productivity or quality of the stands may be linked to unsuitable site-species matching, poor seedling source or inadequate silvicultural management. Lack of technical knowledge or training is often mentioned as limiting farmers' silvicultural activity (e.g. Gunasena and Roshetko 2000; Byron 2001). However, as observed by Byron (2001) and Walters et al. (2005), the success of tree planting or management is rarely due to only technical factors. Several authors working in the tropics and sub-tropics have found that socio-economic, perceptional and motivational factors affect farmers' activity on tree planting (Ravindran and Thomas 2000; Salam et al. 2000; Mahapatra and Mitchell 2001; Simmons et al. 2002; Emtage and Suh 2004), and silvicultural management (Amacher et al. 1993; Current et al. 1995; Summers et al. 2004).

In addition to the studies focusing on farmers' socio-economic or motivational characteristics, several other perspectives for farmers' adaptation of management strategies exists in the literature. These perspectives—as listed by Walters et al. (2005)—include information sharing (Lionberger 1960), local knowledge (Redford and Padoch 1992), economic scarcities (Arnold and Dewees 1997; Mercer 2004), geographic location of the plantation (Deewes and Saxena 1997) and socio-political structures, government policies and incentives (Blundell and Gullison 2003). If targeted well, the presence of external actors promoting tree planting and providing

incentives encourages farmers to plant trees (Enters et al. 2004). However, Haltia and Keipi (1999) pointed out that if incentives are the only reason for a farmer to plant trees, plantation management leading to high yields and timber quality is not necessarily guaranteed.

Participation in social organisations—including farmer groups—is recognised as helping farmers to learn better farming practices (Bebbington 1996). Furthermore, if farmers are collectively organised, it may help them to establish and manage their plantations in a more profitable way, and even to sell their small amounts of wood for a higher price, especially if the wood is of a special quality (Scherr 2004).

Walters et al. (2005) argued that holistic methods should be applied to study why farmers have adapted particular practices. Even the history of individuals and villages and specific events influence farmer adaptation of practices (Walters et al. 1999). Finally, it should be noted that farmers' perceptions and motivations, as well as resource stocks, institutional factors and demand for wood products all can change over time (Filius 1997; Nibbering 1999).

A study was conducted on farmers' silvicultural activity and practices in tree planting in two villages in Tanah Laut District, South Kalimantan Province, Indonesia. The aim was to analyse (1) which socio-economic factors influence farmers' silvicultural activity, (2) which silvicultural practices farmers currently apply, and (3) whether current silvicultural practices affect the quality of plantations. The selected study sites provided an opportunity to address the research questions under two distinct settings of tree planting, but the aim was not to compare statistically the two species or the socio-economic differences between the two groups. The socio-economic, perceptional, and market-related variables used in this study were drawn from a range of studies referred to above. Byron (2001), for example, pointed out that smallholder tree planting can only be successful if all the 'keys' of successful tree planting are in place (secure property rights to land and tree crops, a viable production technology, capacity for crop protection, and access to markets); in this study several of these 'key' factors were analysed.

Understanding the socio-economic and motivational factors of farmers and their implications for the quality of stands is useful for designing appropriate tree planting programs and related policies. If farmers can produce wood of required quality and obtain reasonable prices, tree planting can potentially improve farmers' income (Scherr 1997, 2004). In this respect, this study is important because little empirical evidence is available on the silvicultural activity of farmers in a tropical context.

The two species studied were mahogany (*Swietenia macrophylla* King), locally known as *mahoni,* and kadam (*Anthocephalus cadamba* Miq.) or *jabon.* Kadam is a native, fast-growing tree species producing timber used for plywood and light construction (Soerianegara and Lemmens 1993). Mahogany is an introduced tree species in Indonesia requiring a longer rotation, but producing high quality wood, e.g. for furniture production (Martawijaya et al. 1981; Soerianegara and Lemmens 1993). The recommended silvicultural practices for both species to produce high quality wood include: land preparation, infilling planting gaps, weeding, fertilising, protection and thinning. In addition, pruning is required for mahogany starting at the age of 6–9 months, and continuing during the first 3 years after planting (Direktorat

Hutan Tanaman Industri 1990). Pruning is not needed for kadam stands because kadam is a self-pruning (Soerianegara and Lemmens 1993). Thinning of mahogany stands is recommended to start after 6 years and continue to reduce the stocking to 220–240 stems per hectare at the age of 20 years (Direktorat Hutan Tanaman Industri 1990; Mindawati and Tata 2001). The first thinning for kadam is recommended at age of 3 years (Martawijaya et al. 1981). In this study both mahogany and kadam plantations were still young (maximum 5 years old when the inventory was carried out). The planned end-use for mahogany was wood for furniture production by the company located in the neighbouring sub-district and thus the quality of the wood needed to meet company's requirements. Farmers could potentially obtain a higher price for high quality wood with a minimum diameter of 20 cm (Chaniago 2009). Kadam wood was originally supposed to supply a plywood factory, but its end-use became uncertain because the company that provided the seedlings and was willing to purchase the wood shut down operations. Nevertheless, if markets for kadam wood are found it would be beneficial for the farmers to produce high quality kadam wood as well.

The structure of the paper is as follows: first the study sites and the research method are described, followed by descriptions of farmers' silvicultural activity, management practices adopted, and factors affecting farmers' silvicultural activity. The current quality of stands and the relationship between stand quality and silvicultural practices are then discussed. Finally, ideas for future research are suggested and policy implications are drawn.

The Study Sites

Based on rapid appraisals, two villages were selected as study sites, namely Ranggang Village (3°50′14.265″ S, 125°19′31.691″ E) in Takisung Sub-district, and Asem Jaya Village (formerly Trans 400) (3°57′37″ S, 115°02′6.9″ E) in Jorong Sub-district. Both sites are located in the district of Tanah Laut, South Kalimantan. This district is located in the humid tropical climate zone, with mean annual rainfall of 2,766 mm and mean annual temperature of 27.1°C (Situs Resmi Pemerintah Kabupaten Tanah Laut, undated). The main income sources in both villages are agriculture and rubber production. The sites were selected because they both have active tree planting for timber production, and they differ in several important aspects, providing contrasting cases of tree planting activity. The study focus in Ranggang Village was on farmers planting mahogany. Most of the farmers had received mahogany seedlings from the government forest plantation program, which started in the village in 2003. Farmers can sell mahogany to a company producing furniture located in a neighbouring sub-district. In Asem Jaya the study focus was on farmers planting kadam. The farmers there received kadam seedlings from a plywood company. Most of the farmers in both villages planted several other tree species on their land, mainly fruit trees and rubber (*Hevea brasiliensis* Muell. Arg), but these were not included in the analyses because they are not primarily wood-producing species.

Research Method

Key informant interviews, participatory mapping and wealth ranking were conducted in the selected villages to collect base information on the villages, and mahogany and kadam planters, as well as to group respondents by wealth category (poor, moderate, wealthy). The aim was to select the respondents randomly in proportion to the wealth ranking from the population of 738 households in Ranggang and 383 in Asem Jaya. However, the sample design was modified in that all the available kadam and mahogany planters that planted trees in multiple rows with regular spacing were included, excluding farmers that planted trees on the borders of the land.

Two questionnaires were developed, on socio-economic and silvicultural aspects. Interviews were conducted at farmers' houses by trained enumerators from the local Forestry Research Institute of Banjarbaru. The socio-economic questionnaire included questions on farm and household characteristics, including the number of household members, age, gender, education, occupation, land ownership, income sources, expenses, assets, and participation in farmer's groups or other social organisations. The silvicultural questionnaire included questions on (1) farmers' selection of species, silvicultural knowledge and practices, and (2) farmers' motivations and attitudes towards tree planting. The questionnaires were tested by interviewing several farmers and some questions were modified. The questionnaires were then administered to all the farmers, and additionally the questions related to farmers' silvicultural practices were applied for each stand separately. For mahogany, data were collected from 21 farmers with 27 stands, including 66 plots; the respective numbers for kadam were 30, 34 and 83.

In order to study the relationship between socio-economic factors and farmers' silvicultural activity, data were analysed using Spearman correlations, descriptive statistics, Mann–Whitney tests and cross tabulations (following Ranta et al. 1994).

For each stand a grade of silvicultural activity was determined by assigning one to four points for a kadam stand, and one to five points for a mahogany stand. For kadam stands the four recommended practices were: land preparation, infilling, weeding and fertilising. Additionally, pruning was recommended for mahogany. Protection of stands from any natural or human-caused disturbances leading to defects in growth or quality was recommended for both species if necessary. However, because the type of protection needed is site specific, it was not considered in the analysis of the grade of silvicultural activity. Also, the timing and frequency of the practices, and how the practices were conducted, were not considered when grouping the stands into grades of silvicultural activity.

All the stands of the selected farmers were inventoried. The unit of analysis was a stand planted by a farmer with an area of 0.1 ha or greater and containing a minimum of 50 trees. The aim was to measure 20 trees per sample plot, and to establish one or more fixed area sample plots in each stand depending on stand size and planting density. Each stand was classified using visual observations into one of the following three stand quality groups: (1) well-maintained trees in generally good condition; (2) overall condition acceptable, some problems are

likely to appear; (3) poorly managed, and success or survival of stand doubtful. Diameter at breast height was measured for each tree. Total tree height and the height of the crown base were measured for 25–30% of the trees in each plot. The height of the crown base (the first major branch) was used to calculate the volume of the potentially merchantable wood as a variable in this study. Thus the volume of potentially merchantable wood was the current branchless part of the wood that contributed to the potential amount of merchantable wood, even though the young age of the stands meant that no wood was as yet saleable. Each tree was classified into one of the following stem quality classes with regard to higher value uses (sawn wood): (1) high, no major irregularities or defects; (2) medium, in part usable as sawn wood, some defects; (3) poor, unsuited for sawn wood, too many defects. In addition, trees were classified in three groups according to overall tree condition with respect to viability and growth potential: (1) dominant, in the upper crown layer and superior to immediate neighbours; (2) sub-dominant, in the lower crown layer and receiving less light, smaller than immediate neighbours; (3) others, all trees that neither had major nor medium irregularities and defects, that are not in groups 1 and 2.

Each site where the plots were situated was classified as high, medium or low in quality according to the dominant height. This was done by comparing the mean height of the dominant trees of the plot with the dominant height of mahogany and kadam taken from the preliminary yield tables constructed by Suharlan et al. (1975). This approach may result in some bias in site quality assessment, but was used because of limited knowledge of the quality of the study sites. The relationship between plantation quality and the silvicultural practices applied by the farmers was analysed with descriptive statistics and by hypothesizing and statistically fitting a general linear model. In order to study whether silvicultural practices affect plot quality the volume of potentially merchantable wood was used as a quality indicator. This part of the study was conducted at the plot level instead of the stand level because tree density and site quality sometimes varied among the plots within a stand. Tree age and practices conducted were always the same within a stand.

Because most of the farmers carried out land preparation, fertilising and weeding in their plots, whether the farmer conducted these activities per se probably did not cause variation in the volume of potentially merchantable wood among plots. Pruning was selected for a closer look as to whether it had any effect on mahogany plot quality. According to Soerianegara and Lemmens (1993), pruning is an important practice for improving the stem quality of mahogany. Protection was not studied further because protection type and necessity varied among stands. The effect of infilling was also not studied further, because the need for infilling varied among plots along with the mortality rate.

A general linear model ($n = 66$) was hypothesized to test whether pruning had an effect on the volume of potentially merchantable wood. The null hypothesis was that pruning, site quality, stand age, and tree density did not affect the volume of potentially merchantable wood. Plot age and tree density were the covariates in the model, and site quality and pruning treatment were the fixed factors.

Results

Silvicultural Practices and Activity

Almost all of the farmers conducted more than half of the recommended silvicultural practices. The mean grade of silvicultural activity was 4.22 (SD = 0.85) out of 5 in mahogany stands, and 3.35 (SD = 0.12) out of 4 in kadam stands (Fig. 1). Plantation age, tree species and end-use of trees affected the need for management.

Almost all mahogany and kadam planters personally conducted silvicultural practices, having learnt about the practices mostly through their own experience or from other tree planters (Table 1). Almost all the farmers prepared the land, fertilised and weeded, regardless of the species planted (Table 2). Fertiliser was mainly placed into planting holes before planting. Fertilising was recognised as an important practice in order to improve wood production by 49% of the farmers. Obtaining the relatively expensive fertilizers, however, was mentioned as the main problem related to tree planting, especially in the case of mahogany planting.

Infilling was done in approximately half the mahogany (56%) and kadam (50%) stands, even though the mortality was more than 20% in only 9% of mahogany stands and only 4% of kadam stands. Relatively active infilling may reflect farmers' interest in stand productivity, but also indicates that they had low-cost access to seedlings.

Most of the mahogany planters pruned their stands, the mean age for the first pruning being 1.04 years, and the range from under 1 to 3 years. Pruning was

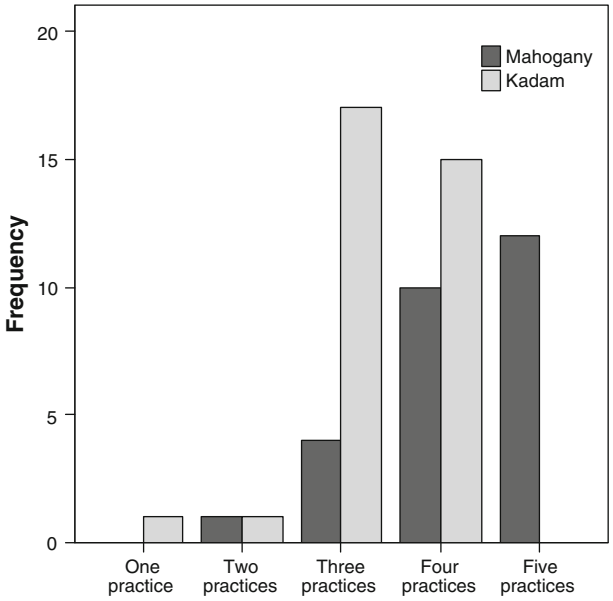

Fig. 1 Number of silvicultural practices conducted by farmers by species (number of stands: mahogany $n = 27$, kadam $n = 34$)

Table 1 Source from which farmers learnt about silvicultural practices

Sourcke	Mahogany		Kadam		Total	
	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)
Other planters	8	38	13	45	21	42
Government	4	19	0	0	4	8
Company	0	0	4	14	4	8
Farmer's group	6	29	3	10	9	18
Own experience	3	14	9	31	12	24
Total	21	100	29	100	50	100

Number of mahogany planting farmers $n = 21$, kadam planting farmers $n = 29$

Table 2 Percentages of the stands where specific silvicultural practices have been conducted

Management activity	Mahogany (%)	Kadam (%)	Total (%)
Land preparation	96	94	95
Fertilizing	100	91	95
Infilling	56	50	53
Weeding	93	97	95
Pruning	78	6	38
Protection	19	35	28
Thinning	0	0	0

Number of stands: mahogany $n = 27$, kadam $n = 34$

important especially in order to remove the threat of shoot-borers. None of the farmers thinned their plantations. Thinning was not even required in the studied kadam and mahogany stands because these were still young and the planting density was low because several farmers planted agricultural crops between the tree lines. Only 17% of the farmers carried out any protection activities in their stands, and only for fire prevention.

Farmers had not yet gained experience in harvesting and selling mahogany or kadam wood. Some of the farmers had, however, experience in harvesting other species. Some mahogany planters (39%) had a planned rotation length for their stands, ranging from 10 to 25 years. The main determinant factor mentioned for rotation length was when the trees reaching merchantable size. More than half the farmers indicated, however, that they did not know how to estimate the yield (Table 3). Most of the kadam planters (85%) did not have a planned rotation length, probably due to the current uncertainty regarding potential buyers.

Approximately half (44%) of the mahogany planting farmers, and one-third of those planting kadam, conducted management activities together with other tree planters. When such activities took place it was mainly in the form of fire protection for mahogany planters and tree planting for kadam planters. Joint management was conducted mainly in order to improve effectiveness in terms of time required for forestry activities, but also for social reasons. More than half the farmers had ideas on what further activities could be done with other tree planters, the activities

Table 3 Qualitative characteristics describing farmers and their forestry stands

Characteristic	Mahogany		Kadam		Total	
	n	Yes %	*n*	Yes %	*n*	Yes %
Decided themselves which species to plant	27	78	33	21	60	47
Conducts silvicultural management themself	27	100	34	97	61	98
Can measure stand yield	20	25	23	9	43	16
Has clear land title over tree plantation land	26	92	34	94	60	93
Received seedlings as incentives	27	100	34	85	61	92
Received economic incentives	27	93	34	3	61	43
Received training	27	37	34	21	61	28
Mentioned economic motivation for tree planting	26	100	32	97	58	98
Has favourable or highly favourable attitude towards tree planting	27	100	34	73	61	85
Joined farmer's group	27	89	34	77	61	82
Joined any social organization	27	96	34	91	61	93

Number of stands: mahogany $n = 27$, kadam $n = 34$

Table 4 Joint management activities conducted by farmers, reasons for conducting them, and future ideas for joint management

Joint management	Number of mahogany farmers	Number of kadam farmers
Conduct joint management	12	9
Joint management activity conducted:		
Tree planting	1	4
Road building	1	1
Fire protection	9	0
Maintenance	1	2
Wood marketing	1	0
Reason for conducting joint management:		
Social reason	4	4
Improve effectiveness	7	8
Ideas for future joint management:		
Tree planting	2	2
Road building	0	11
Nursery	1	0
Wood marketing	1	0
Fire protection	10	0
Pest protection	1	0
Other management	1	0

Number of stands: mahogany $n = 27$, kadam $n = 30$

mentioned most often being fire control and road building to improve stand accessibility. Mahogany planters had the most ideas on how to improve joint activities (Table 4).

Factors Affecting the Grade of Silvicultural Activity of Farmers

Possible correlations between the grade of silvicultural activity and the socio-economic characteristics of farmer, household and stand were analysed. Farmers who planted mahogany in more than one woodlot also conducted more silvicultural practices. This was not the case with kadam planters. The field team even observed that some of the kadam planters had cut some of their stands and replaced them with rubber trees. The reasons given were financial, in that farmers were not confident in the future market for their kadam wood after the company that initially supported kadam planting became bankrupt. In addition, they had enough resources to change the species. In Table 5 the opposite correlation signs (between the species) of the grade of silvicultural activity and the socio-economic variables in 7 of the 12 cases were mainly caused by a difference in market conditions between the villages. For example, even though not statistically significant, mahogany planters with more household assets and existing markets conducted more silvicultural practices, while kadam planters with more household assets but no markets did not conduct more silvicultural practices.

For kadam planters the number of household members contributing to income earning and duration of membership in the farmer's group was positively correlated with their silvicultural activity. No significant difference was detected for mahogany planters. Age of farmer, years of education of the farmer, number of household members, distance to stand, and household assets and expenses were not significantly correlated with the grade of silvicultural activity (Table 5).

Table 5 Farmers' socio-economic characteristics, and Spearman correlations for grade of silvicultural management and socio-economic variables

Variable	Mahogany planters				Kadam planters			
	n	Mean	SD	*r*	*n*	Mean	SD	*r*
Age of farmer (years)	27	45.41	11.70	−0.25	31	50.11	11.59	−0.13
Number of household members	27	3.89	1.01	0.01	34	4.18	1.34	−0.19
Number of income-earning household members	27	1.78	0.89	−0.07	34	1.74	0.86	0.36*
Total farm area (ha)	27	3.08	1.55	0.12	34	3.29	3.29	−0.21
Total area planted to mahogany/kadam (ha)	27	1.50	1.13	0.28	34	1.01	1.48	−0.31
Percentage of planted area of total land area (%)	27	50.03	28.95	0.26	34	37.86	27.48	−0.08
Number of woodlots planted to mahogany or kadam	27	1.59	0.93	0.49*	34	1.50	0.78	−0.23
Distance from plantation to farmer's house (km)	12	1.05	0.73	–0.13	23	0.56	0.42	−0.18
Total value of household assets (millions IRp (2008)/year)	27	34.74	31.30	0.10	34	14.26	14.10	−0.08
Household total expenses (millions IRp (2008)/year)	26	19.02	13.04	0.13	33	12.61	9.61	0.31
Education (years of study)	25	7.44	2.62	0.29	32	6.66	3.71	0.06
Years of membership in farmer's group	21	9.36	4.71	0.33	23	7.53	7.39	0.43*

Number of stands: mahogany $n = 27$, kadam $n = 34$

* $P < 0.05$

Table 6 Number of silvicultural practices conducted by kadam planting farmers cross tabulated with farmers' attitudes towards tree planting

Grade of management	Favourable or highly favourable		Indifferent or unfavourable		Total	
	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)
One practice	1	4	0	0	1	3
Two practices	0	0	1	11	1	3
Three practices	10	40	7	78	17	50
Four practices	14	56	1	11	15	44
Total	25	100	9	100	34	100

Number of kadam stands $n = 34$

The differences between the socio-economic characteristics of the mahogany and kadam farmers were not statistically analysed, but a comparison of descriptive statistics between the two farmer's groups is informative. Table 5 reveals that mahogany planters were on average younger, and had fewer household members, more income-earning family members, smaller total land area, a larger proportion of land planted with trees, plantations located greater distances from their houses, higher total assets and yearly expenses, more years of education, and higher participation in farmer's groups compared to the kadam planters (Table 5).

Within the groups of mahogany and kadam planting farmers, the farmers had similar characteristics in regard to land ownership, planting motivation, species selection, seedlings or economic incentives they received, and whether they joined the farmer's group or another social organisation (Table 3). Thus the variation in farmers' silvicultural activity was probably not caused by these characteristics. Because the farmers generally shared the characteristics mentioned above these results were not analysed statistically.

Almost all farmers interviewed held legal land ownership for their tree stands, and mentioned economic motivation for tree planting. Most of the mahogany planters had decided by themselves to plant mahogany, while most of the kadam planters' decision on species selection was influenced by the company that provided the seedlings. Attitudes towards tree planting among mahogany planters were without exception either favourable or highly favourable, but among kadam planters almost 30% had indifferent or unfavourable attitudes towards tree planting (probably due to the uncertain markets for kadam wood). Almost half the kadam planters mentioned during the interviews the lack of markets or income source as a disadvantage related to tree planting. Kadam farmers with favourable or highly favourable attitudes towards tree planting conducted more silvicultural practices on their land ($P < 0.05$). This was tested using Fishers' exact test, because of the small sample size. Kadam farmers having a favourable or highly favourable attitude towards tree planting more often carried out all four required silvicultural practices than farmers with indifferent or unfavourable attitudes towards tree planting (Table 6).

Table 7 Grade of silvicultural management of mahogany planting farmers cross tabulated with status of training received for tree planting

Grade	Received training for tree planting					
	Yes		No		Total	
	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)
Two practices	0	0	1	6	1	4
Three practices	0	0	4	24	4	15
Four practices	4	40	6	35	10	37
Five practices	6	60	6	35	12	44
Total	10	100	17	100	27	100

Number of mahogany stands $n = 27$

All the kadam planters received the seedlings as an incentive from the company, while mahogany planters received seedlings mainly from the government (57%) or from the farmer's group (30%). Farmers stated that seedlings were mostly easy to obtain (86%) and that seedling quality was mainly good (56%) or moderate (39%) for both tree species. Most of the mahogany planters received financial incentives for initial plantation establishment, while only one kadam planter had received a financial incentive.

Almost all farmers in this study belonged to a farmer's group, thus participation in the farmer's group per se did not explain the variety in farmers' silvicultural activity (Table 3). Among kadam planters, however, those who had belonged to a farmer's group for a longer period of time were more active in applying silvicultural practices. In addition, being a farmer's group member helped farmers learn silvicultural practices from other tree planters. Approximately half the mahogany and kadam planters stated that they had learnt silvicultural practices from other tree planters or from the farmer's group (Table 1). In addition, farmers could probably more easily obtain seedlings from the government or company collectively than individually. It may even become easier to sell the wood to the company collectively, at least in the case of mahogany.

Mahogany-planting farmers who received training always applied four or five of the recommended silvicultural practices, while farmers who did not receive training applied fewer practices (Table 7). However, the difference between the silvicultural activity within the groups of farmers receiving or not receiving training was not statistically significant. The training received by mahogany planters was on seedling preparation and planting techniques.

Quality of Stands

The growth characteristics of plots are summarized in Table 8 as mean, minimum and maximum values of all the measured plots by species. For mahogany stands the proportion of potentially merchantable wood (m^3/ha) of the total tree volume (m^3/ha) varied from 13 to 73%, while for kadam the range was between 68 and 86%. Most of

Table 8 Summary of inventory data

Variable	Mahogany			Kadam		
	Mean	Min	Max	Mean	Min	Max
Distance from farmer's house to stand (km)	1.60	0.20	3.20	0.55	0	1.00
Age of stand (years)	3.78	1.00	5.00	4.03	3.00	5.00
Tree diameter 1.3 (cm)	8.44	0.50	58.20	11.84	1.70	25.30
Tree height (m)	6.27	0.68	11.80	8.29	2.20	17.10
Basal area (m^2/ha)	3.60	0.11	11.37	8.61	1.88	17.16
Stand volume (m^3/ha)	13.47	0.80	42.00	36.04	4.02	110.77
Merchantable volume of stand (m^3/ha)	7.34	0.10	20.84	30.79	2.75	94.95
Planting density (trees/ha)	578	389	917	747	440	1,375
Actual density (trees/ha)	533	280	875	727	360	1,375
Mortality (%)	7.48	0	41.67	3.00	0	25.00

Number of trees measured: mahogany $n = 1{,}408$, kadam $n = 1{,}913$; number of plots: mahogany $n = 66$, kadam $n = 83$

Table 9 Observed stand qualities for mahogany ($n = 27$) and kadam ($n = 34$)

Observed stand quality	Mahogany		Kadam	
	Frequency	Relative frequency (%)	Frequency	Relative frequency (%)
Low	5	19	5	15
Medium	9	33	16	47
High	13	48	13	38
Total	27	100	34	100

the mahogany stands were of high observed quality, and the kadam stands of medium observed quality (Table 9). The mean percentage of high-quality stems in the mahogany plots was approximately 50%, and for kadam approximately 60%. The plots with higher percentages of dominant trees also had more high quality stems ($P = 0.000$), meaning that dominant trees often had high quality stems.

Most of the farmers planting mahogany or kadam indicated that the performance of their stands was high. Comparing observations of the field team and the farmers' perceptions on stand quality, it was found that 48% of the observations were the same, 41% of the observations varied by one quality class and 11% varied by two quality classes, without any constant direction of variation. Most of the mahogany planting farmers indicated that they compared the quality of their stands with the stands of other farmers, especially naming two farmers who had several mahogany stands with active management. Both of these farmers were active 'leaders' in the village (e.g. farmer's group leader and sub-village leader) and their woodlots were regularly measured by university students for educational purposes. In Ranggang

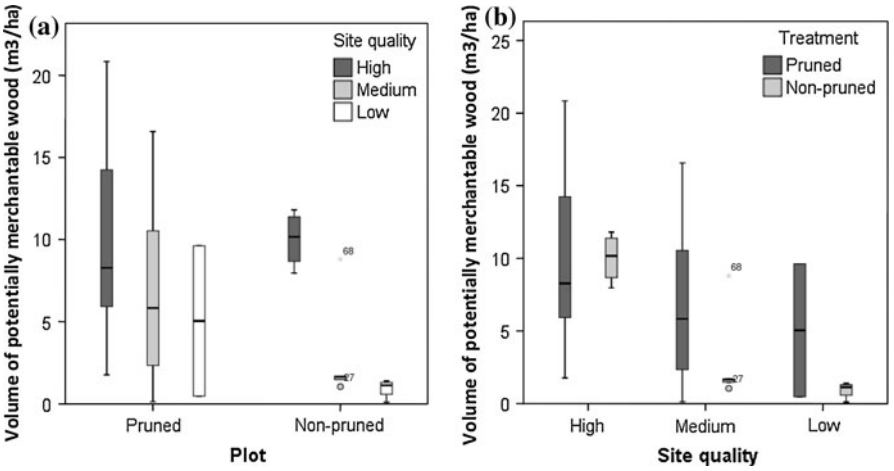

Fig. 2 **a** Volume of potentially merchantable wood of pruned ($n = 53$) and non-pruned ($n = 13$) mahogany plots for three site qualities. **b** Volume of potentially merchantable wood in high quality sites ($n = 25$), medium quality sites ($n = 35$) and low quality sites ($n = 6$) in pruned and non-pruned mahogany plots

village, the secretary of the farmer's group was a government officer advising farmers on agricultural practices who was strongly motivated and skilled in mahogany planting and management. He also helped to manage the woodlots of the farmer's group leader. These well-managed woodlots receiving attention from motivated farmers played an important role for other mahogany planters as visual demonstration plots. Even the enthusiasm of the farmer's group representatives may have encouraged other farmers in regard to mahogany planting and management. Most of members of the farmer's group were from the same Javanese origin, which could have facilitated them to act collectively.

Silvicultural Practices and Stand Quality

Whether the plots were pruned did not affect the volume of potentially merchantable wood ($P = 0.283$). Instead the statistically significant factors were site quality ($P = 0.036$), plot age ($P = 0.000$) and tree density ($P = 0.000$). In both pruned and the non-pruned plots the volume of potentially merchantable wood was higher in higher-quality sites (Fig. 2a). The volume of potentially merchantable wood of pruned and non-pruned plots did not vary significantly within a single site quality (Fig. 2b).

The variation in volume of potentially merchantable wood was higher in pruned than non-pruned plots (Fig. 2a). In addition to varying plot ages and planting densities, the variation may have been caused by timing of pruning and growth recovery time from pruning, pruning method, pruning intensity and percentage of dominant or sub-dominant trees in the plot. In medium-quality sites the volume of potentially merchantable wood was positively correlated with the percentage of dominant trees ($P = 0.000$), with timing of the first pruning ($P = 0.004$) and with

the time to recover from pruning ($P = 0.019$). In the high-quality sites no correlation between pruning timing or tree viability and the volume of potentially merchantable wood was found. This indicates that the timing of pruning caused variation in the volume of potentially merchantable wood in medium quality but not high quality sites. The study did not have enough replicates to analyse the effect of timing of pruning in low quality sites.

Discussion

Among mahogany planters, those with the largest area with trees conducted the most silvicultural practices. Mahogany sites provided a situation where it made sense to allocate land and labour to silvicultural management due to market availability. In kadam planting sites, where the markets were insecure, farmers with enough resources had even felled some off their kadam plantations and replaced them with rubber. This is in line with findings of Byron (2001), whereby it makes sense for the farmers to invest their resources, including land and labour, in tree planting and management if all the 'keys' of successful tree planting are in place.

Previous studies indicate that the availability of labour can have a negative or a positive effect on farmers' tree planting activity (Arnold and Dewees 1997; Ravindran and Thomas 2000; Byron 2001; Summers et al. 2004). In the kadam case the number of household members contributing to income earning was positively correlated with their silvicultural activity. This may mean that more household members were available for working on the farm. Interviews revealed that if a kadam planting household had only one or two members earning income, more often than not these people gained their main income from off-farm work.

Interaction with other farmers—such as in a farmers' group—is found to encourage better farming practices (Bebbington 1996). In this study kadam planters who had been members of the farmer's group for a longer period were more active in silvicultural management. In addition, several farmers stated that they had learnt silvicultural practices from other tree planters or from the farmer's group.

Farmers' attitudes towards tree planting can affect their tree planting behaviour (Mahapatra and Mitchell 2001). In this study, kadam planters with a favourable or highly favourable attitudes towards tree planting carried out more silvicultural practices in their stands.

Forest extension can have a positive effect on tree planting (Salam et al. 2000). Mahogany-planting farmers who received training always applied four or five of the recommended silvicultural practices, while farmers who did not receive training applied fewer practices.

Almost half the mahogany stands and more than a third of kadam stands studied were of high observed quality. Approximately half of the field team's observations on stand quality were similar to farmers' observations. Stands varied with regard to their volume of potentially merchantable wood mainly due to varying age, density and site qualities rather than by whether or not farmers conducted a specific silvicultural practice per se. Age at first pruning, amount of time for recovery from pruning, and percentage of dominant trees in the plot caused variation in the volume

of potentially merchantable wood in the medium quality sites planted with mahogany.

Concluding Comments

This study reveals that success of tree planting is not only affected by technical factors, but that the silvicultural activity is also affected by socio-economic, perceptional and market-related characteristics of each site. The policy implication is that before implementing new tree planting programs, specific characteristics of the sites should be carefully surveyed. It is also important to note that a factor that may have a positive effect on the level of silvicultural management at particular site may have a negative effect at other sites. For example, timber market availability seemed to have a strong effect on the level of the silvicultural management activity, and on whether a specific socio-economic factor had a positive or negative effect on management.

It is probable that the quality of stands can be improved with the help of further research on timing, frequency and methods used for silvicultural management. The farmers interviewed believed that by improving silvicultural management they might achieve better outcomes. Possibilities for improvement of silvicultural management to increase the quality of stands could include establishing trials for fertilising schemes using fertilisers that are easily accessible to farmers, providing training in mahogany pruning techniques and timing, and providing training on yield measuring techniques so as to improve farmers' understanding of the quantity, quality and value of their stands. Notably, measures to improve stand quality may only be justified if a solution can first be found for kadam planters to market their wood.

Whilst the political, environmental and social contexts affecting tree planting are specific to the sites in this study, there are some factors affecting silvicultural management that are common to many other developing nations. Policies are needed that provide farmers with incentives to plant species for which they have already identified markets with reasonable pricing structures. Farmers plant trees mainly for financial reasons, and it is unrealistic to expect them to plant—and especially manage—plantations without expected future income. In addition, more attention is required to providing skilled and motivated extension officers to advise farmers. Government interventions to assist in providing access to production inputs including fertilizer would help to promote tree planting. Finally, there is a need to introduce structures and mechanisms to assist farmers to organize themselves and to develop activities jointly. This would help them to improve the silvicultural management of the stands and to gain access to markets.

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